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**Effects of Landscape and Stand-level Factors on Forest Songbird Populations and
Diversity across a Cottonwood Successional Gradient along the Missouri River**

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Introduction

Floodplain forests have long been recognized as a leading habitat type in terms of songbird density and diversity. With a diverse array of stand types and successional stages available to them, the songbird populations frequenting the cottonwood forests of the middle segments of the Missouri River are no exception. Though extensive work has been done in an effort to catalogue avian species richness and abundance in floodplain forests, research into species associations with a specific stand types or successional stages remains relatively unexplored. Taking a closer look into these species-habitat interactions facilitates a greater understanding of the existing ecosystem and can be a powerful tool in the development of future management approaches.

The floodplain landscape of the Missouri River has historically been dominated by plains cottonwood (*Populus deltoides*) forests. These stands have served as a vital component of the river valley ecosystem of the Missouri and other major Great Plains rivers and provided a crucial source of habitat for wildlife species ranging from whitetailed deer to the Bald Eagle. As an early successional, pioneer species, the cottonwood's dominance of the floodplain has stemmed from its ability to establish on mineral sediment bars produced by a dynamic river. As these cottonwood stands mature through various successional stages they provide a variety of different habitat types before the cottonwood trees themselves die off and are replaced by later successional species such as green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and box elder (*Acer negundo*).

Through river meandering, frequent flooding and ice scouring, the role of cottonwood stands as a major ecological component of the floodplain has, up until the last half century been assured. Beginning with the construction of the six mainstem dams on the Missouri River in the mid 20th century (Ft. Peck in Montana, Garrison in North Dakota and Oahe, Big Bend, Ft. Randall, and Gavins Point in South Dakota) the flow regulation of the Missouri River has led to dramatic changes in the configuration of the floodplain landscape. Flow regulation of the Missouri River (specifically the construction of the mainstem dams) has been cited as the primary cause of a number of ecological problems including channel incision, decreased sediment transport and sandbar formation necessary for populations of endangered bird species, and declines in shallow water habitat necessary for the successful spawning of several riverine fish species. In combination with the filling of reservoirs upstream of the dams, the cessation of major flood events and resulting declines in channel migration have contributed to declines in recruitment of new cottonwood stands. The end result is floodplain with very limited opportunities for the natural development of new cottonwood stands and little means of replacing the existing stands

that are gradually aging and dying off. In addition to loss of older cottonwood forests to non-cottonwood stands through succession, significant forest loss has occurred through clearing for floodplain agriculture or urban/exurban expansion over the last 60 years.

Declines in cottonwood forest area and changes in forest age distribution potentially affect a number of wildlife species. Of these species, breeding populations of songbirds represent a potential environmental indicator of the effects of forest loss within the floodplain of major rivers, with variation in species abundances in different successional stages (e.g., early and late successional) and forest types (cottonwood vs. non-cottonwood). Through research into those species closely tied to the health of the Missouri River's cottonwood forests, a better understanding of the challenges facing the floodplain forest ecosystem can be obtained and a management plan can be adopted to lessen the impacts on songbird abundance and diversity.

Methods

To generate species density estimates, point count surveys were conducted across 78 sites along the 39-mile (Ft. Randall to Niobrara) and 59-mile (Gavins Point to Ponca) segments of the Missouri National Recreational River. Each of the 78 sites was chosen from sites sampled in a previous study (2007-2009) of cottonwood and non-cottonwood riparian forest vegetation by Dr. Mark Dixon along the Missouri River. Approximate stand age was estimated using a time series of historic maps (1892 Missouri River Commission maps) and aerial photography (1955-56, 1983-85, 1997-2000, and 2006) within a Geographic Information System (GIS). Six different classes of stand age/type were delineated and mapped: pole/sapling cottonwood stands (less than 25 years old), intermediate cottonwood stands (25-50 years old), mature cottonwood stands (50-114 years old), old cottonwood stands (greater than 114 years old), young, "post-dam" non-cottonwood stands (<50 years old) and old non-cottonwood stands (>50 years old, originating before the construction of Fort Randall and Gavins Point dams). We selected 5-8 stands per stand age/type and river segment, depending on stand availability and accessibility.

Bird surveys were carried out during the breeding season, between May 25 and July 8, 2009. We are currently (summer 2010) conducting a second summer of surveys. The songbirds within each stand were sampled at two separate points a minimum of 250 meters apart, and generally at least 50 m from the stand edge to insure that the stand itself and not the surrounding landscape was surveyed. Counts were conducted between 5:30 AM and 10 AM, with each point surveyed for ten minutes. Using voice recorders, we recorded species, distance from observer, and time within the 10-minute period at which the bird was first detected. Counts were conducted by three experienced observers - two university professors: Drs. Dixon and Swanson, and a graduate student: Adam Benson. Each site was visited twice per year, with one visit taking place in the first half of the season (before June 14th) and one in the second half. In each year, one visit was by the graduate student and one by one of the two professors. The order that sites were visited was switched between halves of the season, to remove the effect of time of day on abundance estimates for each site. To minimize any differences between observers, the stands visited in the first year of sampling (2009) by one professor will be visited by the other professor in the following year (2010).

Results

Over the course of the 2009 sampling season a total of 6674 detections were recorded across 76 species. Among these detections, the most common species encountered was House Wren (698) followed closely by Yellow Warbler (623), Mourning Dove (509), Baltimore Oriole (443), and Rose-breasted Grosbeak (292). Orchard Oriole, Rufous-sided Towhee (Eastern and Spotted lumped together), Blue Jay, Eastern Wood Pewee, and Brown-headed Cowbird rounded out the top ten most commonly detected species. The greatest number of detections per stand was in the intermediate aged cottonwood stands with the fewest detections found in the older non-cottonwood stands. A complete breakdown of total detections per class and an average of detections per stand (across the two visits) can be seen below in Table 1.

Table 1. Total detections and average detections per stand (for two visits), by stand age/type class.

Class	Total Detections	Average Detection Per Stand
Pole/Sapling Cottonwood (<25)	1149	88.38462
Intermediate Cottonwood (25-50)	1199	92.23077
Mature Cottonwood (50-114)	981	81.75
Old Cottonwood (>114)	1101	84.69231
Post-Dam Non-Cottonwood (<50)	1325	88.33333
Pre-Dam Non-Cottonwood (>50)	918	76.5

Preliminary examination of the data from the 2009 sampling season revealed several species or guilds that appeared to have a strong preference for a specific stand type or age. Among these species were Orchard Oriole, Yellow Warbler, Bell's Vireo, Eastern Wood Pewee, woodpeckers and other cavity nesters as a group. Below, we examine the distribution of abundances (average number of detections per stand) for each of these species or groups across the six stand age/type classes:

Orchard Oriole: With a far greater number of detections in the younger stands, the Orchard Oriole appeared to preferentially choose young stands over older habitat types (Figure 1). Detections per stand within the young cottonwood and young non-cottonwood stands were significantly ($\alpha=0.05$) greater than any other age classes. However, there were no statistically significant differences between stand types (cottonwood versus non-cottonwood) stands.
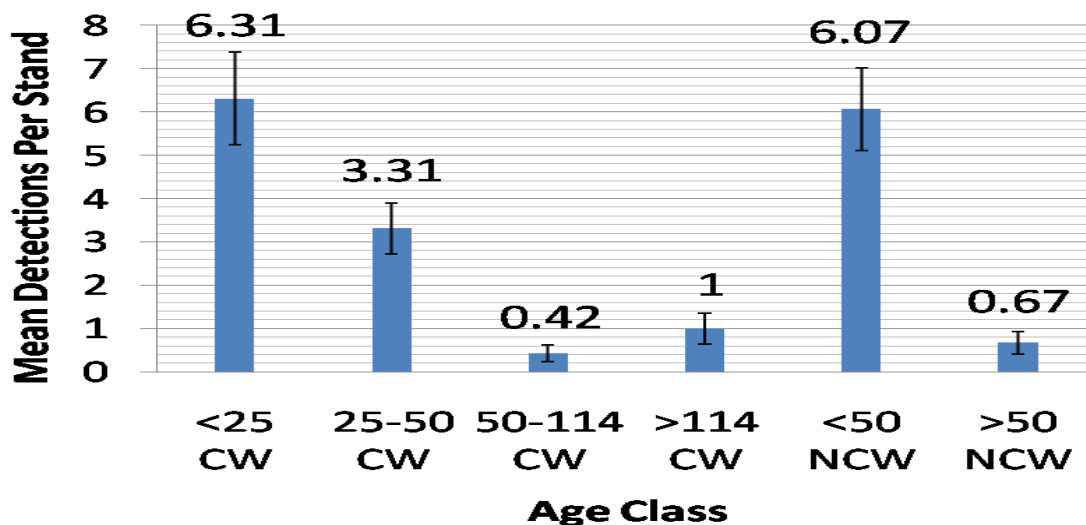
Figure 1. Mean (± SE) number of detections of Orchard Oriole per stand across two visits, by stand age/type class.

Yellow Warbler: Similar to Orchard Oriole, Yellow Warbler also showed a strong connection to younger stands with significantly greater detections in the young and intermediate age stands than in the older stands in both cottonwood and non-cottonwood forests (Figure 2). Again, there was no statistically significant difference between stand types, although abundances appeared to be slightly higher in young cottonwood than in young non-cottonwood stands.
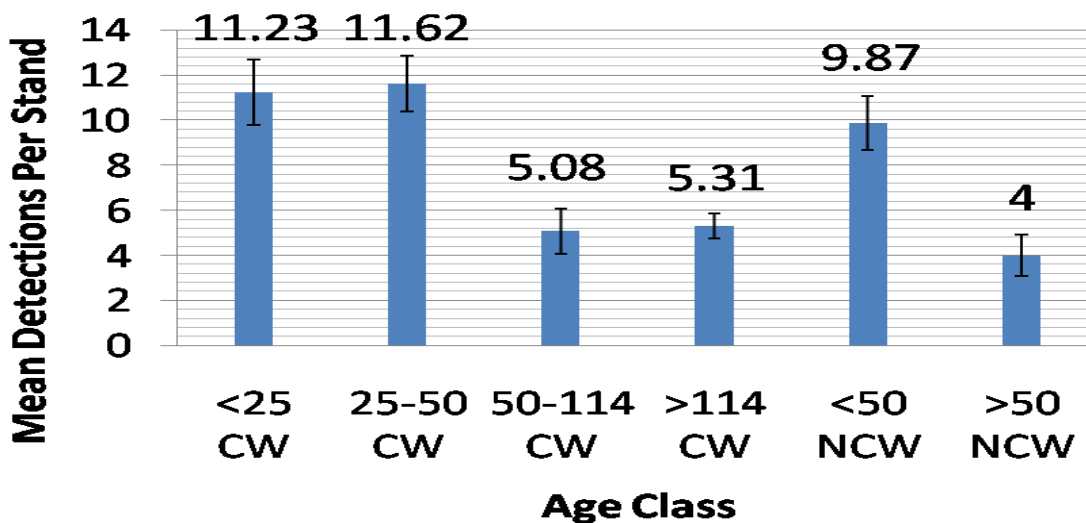

Figure 2. Mean (± SE) number of detections of Yellow Warbler per stand across two visits, by stand age/type class.

Bell's Vireo: Bell's Vireo was another species that preferentially selected younger stands (particularly those with Russian olive trees) over other age classes (Figure 3). The data show extreme differences between detections within younger stands and detections in the older stands. Older stands totaled only four detections across the sampling season as compared to 117 total detections in the younger age classes.
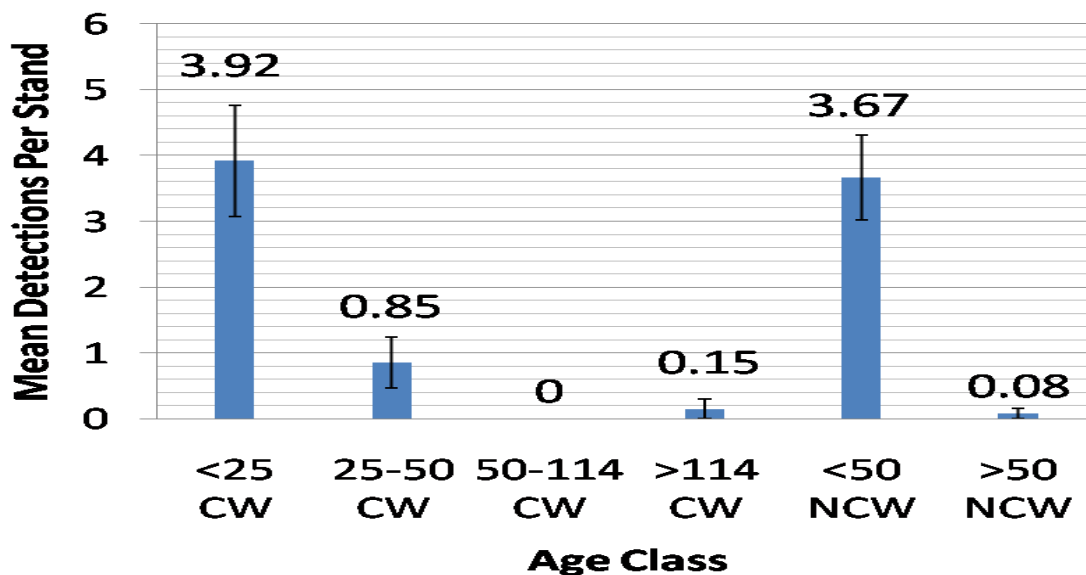
Figure 3. Mean (± SE) number of detections of Bell's Vireo per stand across two visits, by stand age/type class.

Eastern Wood Pewee: The wood pewees are the first species discussed that appeared to prefer the older stands. Detections per cottonwood stand increased with stand age up to the oldest stands (Figure 4). The relationship was similar in non-cottonwood stands. There appears to have been no significant amount of selection based on stand type with both old cottonwood and old non-cottonwood stands averaging approximately four detections per stand.
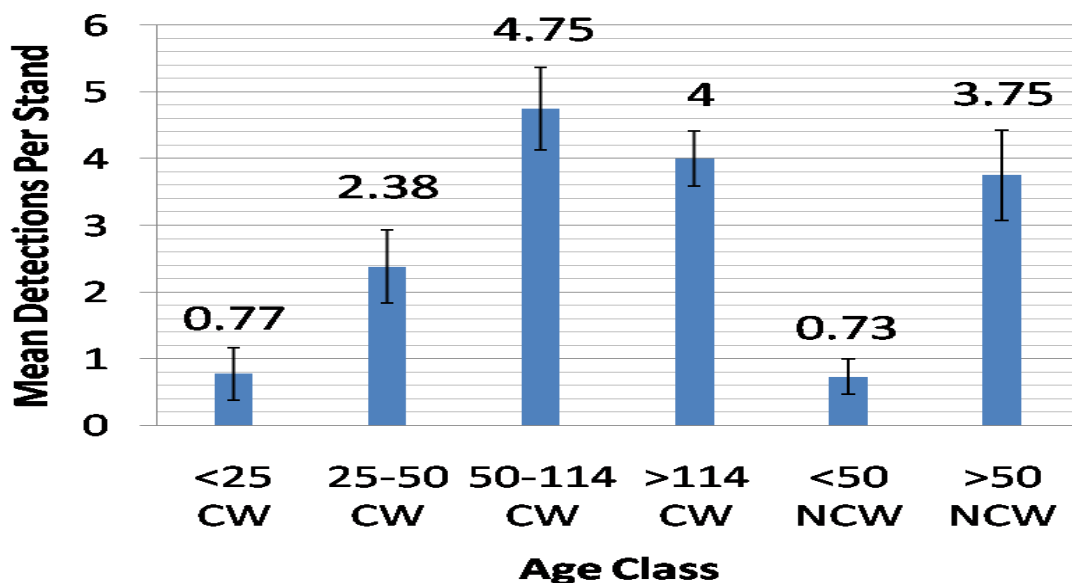

Figure 4. Mean (± SE) number of detections of Eastern Wood Pewee per stand across two visits, by stand age/type class.

Woodpeckers: For the sake of this analysis Red-headed, Downy, Hairy, and Red-bellied Woodpeckers were clustered into a single group. Perhaps due to the greater number of tree cavities or dead snags available in older forests, the woodpeckers clearly showed a preference for the older aged stands (Figure 5). Detections were greater in the older stands than younger stands in both the cottonwood and non-cottonwood forests. Additionally, woodpeckers preferred cottonwood forests over their non-cottonwood counterparts with a significant difference in detections between older stands of opposite classes.
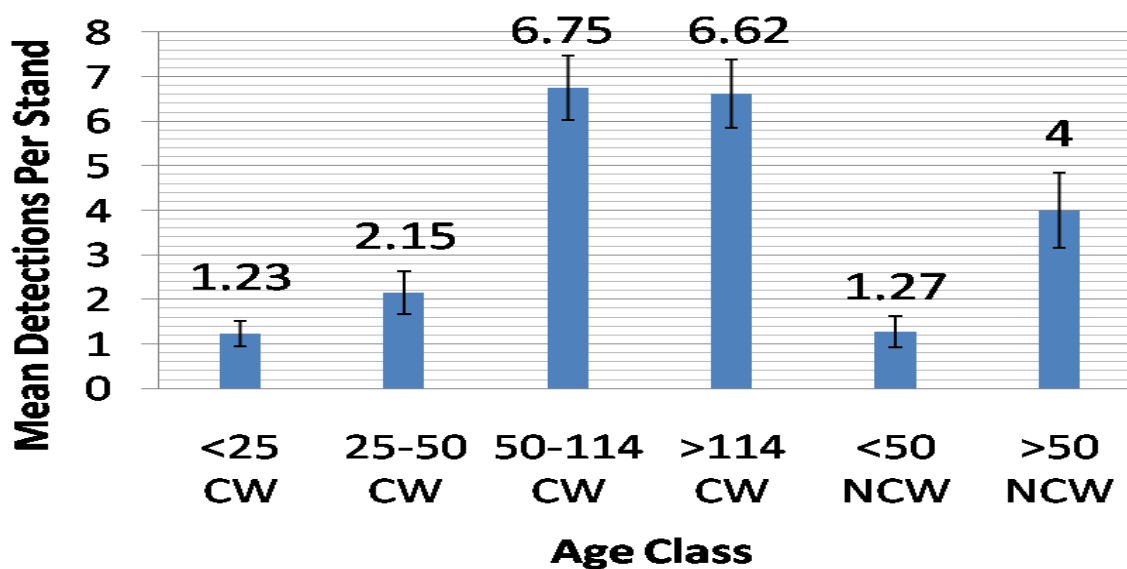

Figure 5. Mean (± SE) number of detections of woodpeckers per stand across two visits, by stand age/type class.

Other Cavity Nesters: Included in this group were Black-capped Chickadee, House Wren, Great Crested Flycatcher, Northern Flicker, and White-breasted Nuthatch. As a group, the cavity nesters, like their fellow cavity dwellers the woodpeckers, were more abundant in older stands with the number of detections per stand increasing significantly with stand age up through the mature to older stands (Figure 6). Similar to the woodpeckers, the cavity nesters were found significantly more often in the mature and old cottonwood stands than in the older (>50 years) non-cottonwood stands.
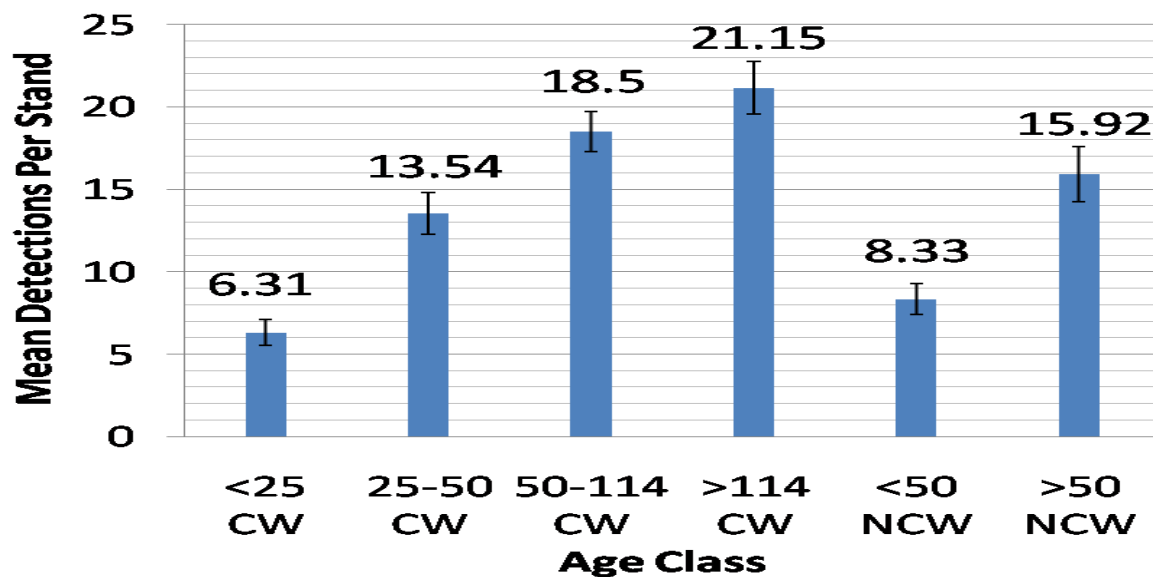
Figure 6. Mean (± SE) number of detections of other cavity nesters per stand across two visits, by stand age/type class.

Discussion

Several interesting patterns emerged from preliminary analyses of the first season of sampling (2009). The first of these is the high species richness associated with the riparian forests along the Missouri National Recreational River. With a total of 76 different bird species detected, the floodplain's forests are a rich and vital component in the overall river valley ecosystem. In addition, several species showed variation in abundance (number of detections) based on stand age class or type (cottonwood vs. non-cottonwood).

Orchard Oriole, Yellow Warbler, and Bell's Vireo are three species that stand out as especially dependant on a specific forest age class. Their strong preference for younger, early successional forests (<50 years) puts them risk as rates of establishment of new cottonwood forests are reduced under current river management practices. Management actions, such as planting efforts, restoration of natural fluvial processes that favor cottonwood recruitment, or other restoration efforts may be needed to ensure that the abundance of these species does not decline in the future.

In contrast to the species above that rely on the younger stands, there are a number of species that were more abundant in older, later successional stands. The woodpeckers and cavity nesters were more abundant in the older (>50 years old) cottonwood stands and preferred older cottonwood forests over old non-cottonwood forests. Over the next few decades, barring extensive forest loss to clearing, abundance of these species may increase as existing cottonwood stands age. Over longer time scales, however, decreased rates of cottonwood recruitment may reduce total cottonwood area, and older cottonwood stands may succeed to non-cottonwood, later successional stands. Declines in total forest area would result in lower habitat availability,

while succession from cottonwood to non-cottonwood would result in lower habitat quality and lower abundances.

Although this report has discussed our initial findings in detail for only a few species, many other species are likely to share similar differences in abundances among stand types and age classes. Ovenbird, American Goldfinch, Common Yellowthroat, Red-eyed Vireo, and Field Sparrow are several species that showed potentially strong relationships with specific stand types but lacked a sufficient number of detections to draw significant conclusions regarding their habitat choices. A second year of sampling (2010) may enable us to obtain sufficient sample size to make conclusions about these and other species.